

Abstract: *In the paper the algorithm of initialisation of video based vehicle tracking systems is presented. It utilises the analysis of chosen frames of the video sequence with the road traffic. The assumption of the algorithm is the usage of the side-view located camera in order to handle all possible locations. As the side-view location can be treated as one of the hardest ones for the tracking purposes, proposed method should be robust to the possible overlapping of the vehicles in many lanes in the analysed video frames.*

KEYWORDS: INTELLIGENT TRANSPORT SYSTEMS, IMAGE ANALYSIS

1. Introduction

Optical car tracking systems can be an efficient solution for Intelligent Transport Systems, especially in the situations where classical approach based e.g. on many inductive loops seem to be too expensive. A serious advantage of the optical approach is the ability of multiple car tracking at the same time, often impossible using classical methods.

In our earlier papers [1,5] some applications of Jump Diffusion Markov Chain Monte Carlo for vehicle tracking purposes have been analysed. Presented method work fine but its main disadvantage is relatively high computational cost.

Nevertheless, such algorithms can be assisted with some image processing and analysis methods which are much faster and can be successfully applied for some pre-processing operations and the initialisation of the main algorithm.

In the paper the algorithm useful for preliminary detection and classification of the vehicles based on the video sequence recorded by the side-view located camera is proposed.

2. Vehicle detection algorithm

One of the essential features of Jump Diffusion Markov Chain Monte Carlo method presented earlier [1,5] is the ability to track many vehicles overlapping each other in the video frames. After the proper localisation of each visible vehicle the extraction of the position and velocity information can be performed analysing the differential information between frames (with the proper assignment).

Our faster method of video data analysis should handle the possible overlapping as well without the necessity of using such sophisticated techniques as the MCMC method.

Probably the simplest and widely used approach to image analysis is the processing of the binary images, especially because of extremely low computational requirements. Similarly as in the Jump Diffusion approach the analysis of the image data in our method can be performed after the binarization.

2.1. Background removal

The first step of the algorithm is related to the background estimation and removal. It may cause some problems especially related to the weather conditions (e.g. trees and leaves in the strong wind). However, even if some of the data not corresponding to the moving vehicles remain in the differential frame (the frame with removed background), it can be ignored in the further analysis because of the shape's mismatch in comparison to the database of vehicles' contours.

Typical background estimation methods are:

- differential detection
- moving average
- moving average with threshold



Fig.1 Example frames taken by the side-view located camera.



Fig.2 Background image obtained in the experiments.



Fig.3 Area of interest on the background image.

The first one is based just on the differences between two neighbouring frames in the video sequence, similarly as in motion detection algorithms and some video compression standards [7].

Unfortunately the usage of such simple method can cause some problems with the proper background estimation, especially for relatively large surfaces (e.g. bonnet or the top of the moving car), which can be wrongly classified as the background particularly for high frame rate video sequences.

In the effect of using Moving Average (MA) algorithm the background information with the presence of some light noise caused by moving vehicles can be achieved. The amount of noise depends on the number of frames in the moving average window.

In real applications there is a high possibility of occurring some random disturbances causing the background instability so additional thresholding can be also used for the elimination of slight color changes of each pixel (possible influence of the CCD noise). As the further modification an algorithm based on pixel's average update have been proposed in the paper [3]. It can adapt to dynamically changing light conditions and is resistant to noise. Nevertheless it requires initialization by the starting background image, which can be obtained by the averaging of the specified number of the first frames.

In order to reduce the computational cost the background estimation can be performed after cutting the images to the area of interest (the fragment of the image where the moving vehicles can appear). Taking into consideration the possible noise cause by the CCD or small moving elements visible on the acquires images (e.g. leaves, flying insects, dust etc.) the background removal algorithm has been supplemented by the image filtering operation using standard low-pass filter with the mask of 5x5 pixels.

The threshold value has been chosen in the RGB colour space as the limit distance between pixels of two images. Such distance is calculated as the Euclidean distance:

$$d = \sqrt{(R_{im} - R_{bg})^2 + (G_{im} - G_{bg})^2 + (B_{im} - B_{bg})^2} \quad (1)$$

where R,G,B denote the red, green and blue channel's values respectively, 'im' stands for the analysed image and 'bg' for the estimated background.

The example cut frames of the analysed video sequence with removed background are shown in Fig. 4.

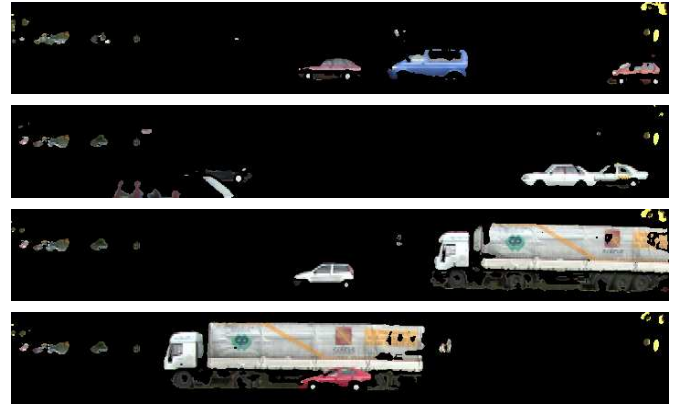


Fig.4 Example frames taken by the side-view located camera with removed background cut to the area of interest.

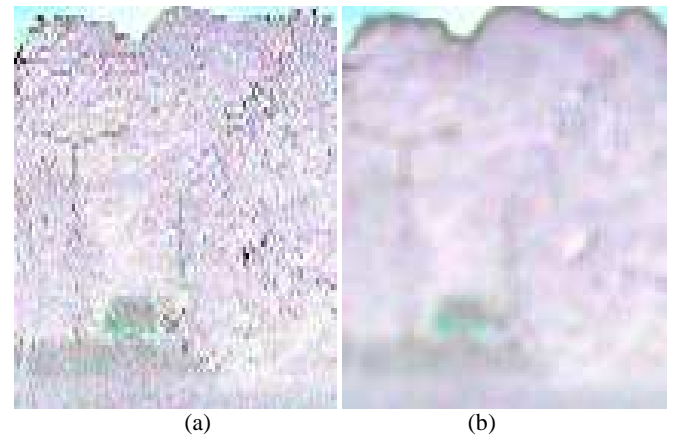


Fig.5 Illustration of denoising using 5x5 pixels low-pass filter: (a) – negative of gamma corrected original difference image, (b) – negative of gamma corrected filtered difference image.

2.2. Processing of the binary difference images

The images obtained after the first step can be binarized rapidly using the non-zero elements as "ones" in the binary images. Such obtained binary image of the considered scene's fragment is compared to the binary images taken from the database of vehicles' shapes. After initialisation (scaling of the images from the database may be needed) the double loop is used in order to calculate Hamming distance between the image from the database and each fragment of the binary image obtained after background removal using sliding window approach. Hamming distance can be calculated as

$$d_H = \sum_i \sum_j (X_{i,j} \oplus Y_{i,j}) \quad (2)$$

where X denotes the pattern and Y – the analysed fragment of the binarized image.

The local minimum values of Hamming distance used as the measure of dissimilarity (after additional thresholding) are treated as the positions of the vehicles of the given type (depending on the type chosen from the database). The example results of such calculations are presented in Fig. 6 (darker areas indicate lower values of Hamming distance) in the same order as in Figs. 1 and 4.

As can be noticed especially on the first two images in Fig. 6 such method works fine only for well separable objects. In the case when such separable vehicle, especially differing from the typical ones, appears on the image (in an expected place on the road) it can be added to the database.

2.3. Processing of the colour difference images

The problems occur when the vehicles cover each other on the image, what is illustrated on the bottom image in Fig. 6. In such case the calculation of Hamming distance for binary images should be replaced by analysis of full colour images using Euclidean distance in the RGB colour space (1). However, the vehicles should be well separated on at least single frame in order to track them directly instead of using the images from the database.

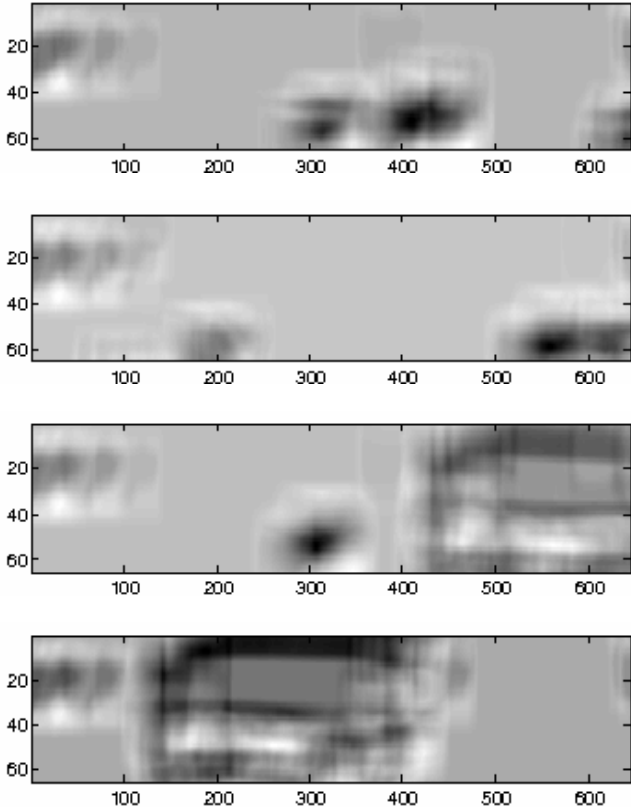


Fig.5 Example results of detection based on Hamming distance.



Fig.6 Example binary mask from the database and the example separable model taken from one of the video frames.



Fig.7 Illustration of the idea of the sliding mask approach – only the values under the black part of the mask are taken into consideration for the specified position of the mask.

In the case when the vehicles are partially separable the algorithm for limited camera’s field of view car recognition systems presented in one of our earlier papers [4] can be used. In the result the combined image can be obtained and further used as the model. The block diagram of the whole algorithm is presented in Fig. 8.

The results obtained using proposed technique are illustrated in Fig. 9. Darker areas indicate higher similarity corresponding to estimated vehicle’s position. As shown in Fig. 9 for the situations where the overlapping is possible using Euclidean distance for searching is a better solution. Nevertheless, the application of Hamming distance for binary images can be also an interesting alternative for well separated objects, especially when the computational complexity of the algorithm is crucial.

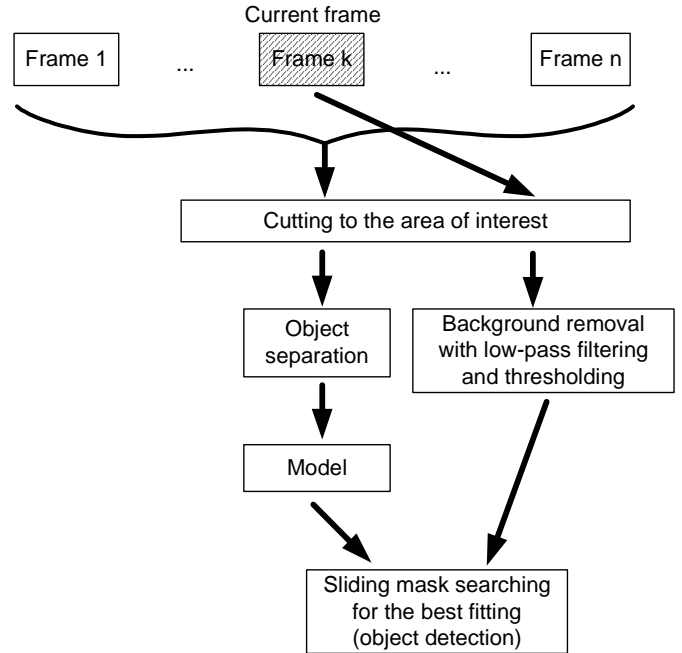


Fig.8 Block diagram of the detection algorithm.

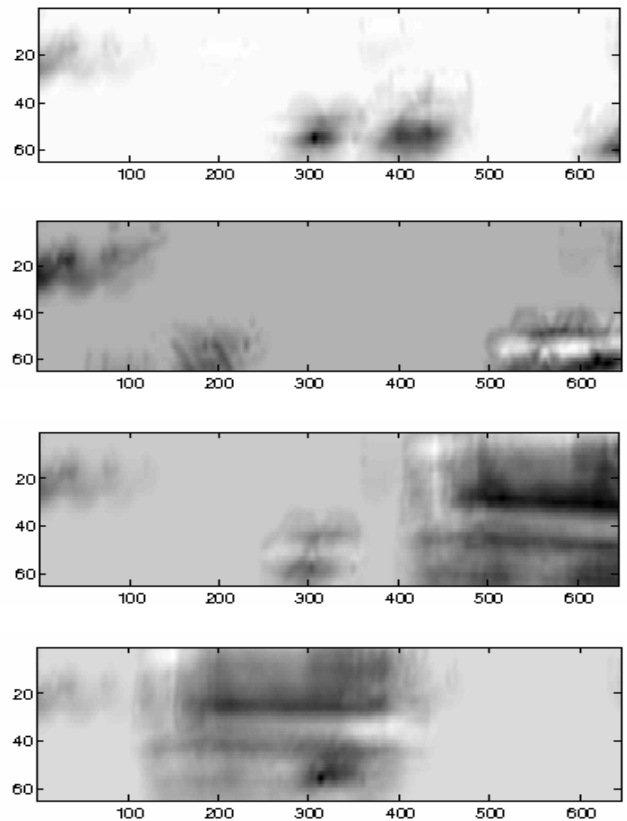


Fig.9 Example results of detection based on Euclidean distance in the RGB colour space.



Fig.10 Illustration of the example results of detection based on Euclidean distance in the RGB colour space.

3. Bibliography

- [1] Mazurek P., Okarma K., Estimation of the vehicles' shapes and spatial locations using Jump Diffusion Markov Chain Monte Carlo method, Scientific Works of Warsaw University of Technology - Transport series, issue 61 „Computer technology in transport systems”, pp. 13-20, 2007
- [2] Mazurek P., Okarma K., Car-by-light tracking approach based on log-likelihood track-before-detect algorithm, Proceedings of the 10-th International Conference of Computer Aided Science, Industrial and Transport TRANSCOMP vol.2 pp. 15-20, December 2006
- [3] Okarma K., Mazurek P., Background estimation algorithm for optical car tracking applications, “Machinebuilding and Electrical Engineering” no. 7-8/2006, pp. 7-10 (Proceedings of XIII International Scientific-Technical Conference trans & motauto'06, vol.2 pp. 144-147, Varna, Bulgaria 26-28 October 2006.
- [4] Mazurek P., Okarma K., Resolution enhancement method for limited camera's field of view car recognition systems, “Machinebuilding and Electrical Engineering” no. 7-8/2006, pp. 11-14 (Proceedings of XIII International Scientific-Technical Conference trans & motauto'06, vol.2 pp. 148-151, Varna, Bulgaria 26-28 October 2006
- [5] Okarma K., Mazurek P., Application of Jump Diffusion Markov Chain Monte Carlo Method to Image Based Traffic Analysis, Journal of Modern Technologies in Transport no. 1/2007, pp. 33-42, Szczecin, Poland, 2007.
- [6] Pratt W. K., Digital Image Processing, Wiley Interscience, 1991.
- [7] MPEG-2 Standard. ISO/IEC 13818-5:2005